Improvements in Means for Localising Metallic Bodies in Human or Animal Tissues or Non-metallic Substances.

Publication number: GB117507
Publication date: 1918-07-25
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Classification:
- international: ***A61B5/06; G01V3/10;*** **A61B5/06; G01V3/10;**
- european: A61B5/06; G01V3/10C2B
Application number: GB19170010721 19170726
Priority number(s): GB19170010721 19170726

Abstract of **GB117507**

117,507. Greenwood. J. W., and Hackett, E. H. July 26, 1917. Locating conductors. - Induction apparatus for detecting the presence of metals in wounds or in any non- metallic substance comprises a primary circuit containing a battery 2, an interrupter 3, a regulating coil 6, and a coil a wound on the same bobbin as a coil b in the secondary circuit which contains also a telephone receiver 23 and a coil 5 co-acting with the coil 6. The coils a, b are mounted within a surfacesearcher or a probe. The whole of the parts are contained in a box 1, Fig. 1, but in use a loose box 4 containing or supporting the regulating-coils 5, 6 together with switches and connexions is mounted on the lid of the box 1, electric connexions being made through plugs 9. A surface searcher 20 containing the coils a, b is detachably connected to the apparatus by a flexible connexion 19, and is formed with an opening 30 for a pencil to mark the location of the metal when found. The searcher 20 may be replaced by a probe 24 containing smaller coils, and in this case part of the windings of the coil 5 are cut out by means of a switch 7 so as to restore the balance. Before use, balance is perfected by adjustment of the coil 6 with reference to the coil 5 by means of a screw spindle 15 and a pointer 16. A condenser 31 is inserted in the primary circuit and in some cases a second condenser, (not shown), may. also be employed in the circuit f, g, e, Fig. 5. The interrupter 3 is mounted on short lengths 28 of india rubber tubing within a small silencing case 4, and is provided with a tongue

FIG.1.

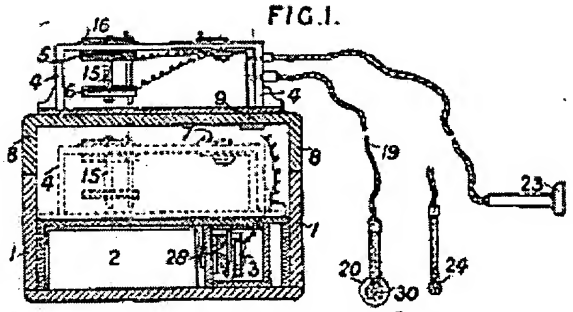
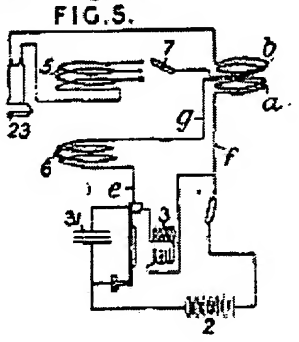


FIG.5.



flexible on both sides of the armature. The receiver 23 may be of the type described in Specification 22887/14, [Class 40 (iv), Telephones &c.]. In a modification the parts may be mounted within a small celluloid case to which a probe searcher is permanently connected. In this form the switch 7 is omitted and the case containing the regulating- coils serve as a surface searcher. The battery 2 may be replaced by a motor generator or other transformer supplied from an ordinary lighting circuit. The instrument may be employed to distinguish magnetic from non-magnetic metals according to the nature of the sounds generated in the receiver 23. According to the Provisional Specification, the regulating-coils may be adjusted by lateral or angular movement

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117,507

PATENT SPECIFICATION

Application Date, July 26, 1917. No. 10,721/17.
Complete Left, Jan. 26, 1918.
Complete Accepted, July 25, 1918.

PROVISIONAL SPECIFICATION.

Improvements in Means for Localising Metallic Bodies in Human or Animal Tissues or Non-metallic Substances.

We, JAMES WILLIAM GREENWOOD, of 49, Cheltenham Place, Halifax, in the County of York, Electrical Engineer, and EDWARD HAWKESWORTH HACKETT, of Heath Mount, Halifax, aforesaid, Surgeon, do hereby declare the nature of this invention to be as follows:—

This invention relates to means or apparatus of the electrical telephonic type for localising foreign bodies or pieces of metal such as bullets, fragments of shrapnel shell and the like lodged in human or animal tissues or of metals in non-metallic substances, and has for its object the provision of improved simple and efficient means by which the position of the metallic body can be accurately located either from the surface of the body or by a probe inserted into the wound or cut without actual contact being made with the metal, as is essential in electrical means heretofore employed for the purpose, said means with a surface or like localiser being also adapted for locating metals in non-metallic substances.

According to our invention, we employ induction in place of direct electrical contact so that by acting inductively on the fragment of metal lodged in the body or in non-metallic substances, by induction coils placed on the surface of the body or substance, or in the wound or cut, the metal in turn will act inductively on another coil also on the surface of the body or substance or in the wound or cut, the currents thus generated being utilized for giving a signal or audible warning of the presence of the metallic body.

Although our improved apparatus may be modified in many ways we will describe the same broadly in the preferred form according to results so far obtained by experiments carried out in the localisation of metallic substances in human or animal tissues.

We employ a suitable intermittent, pulsating or alternating current produced either from cells with suitable apparatus, such as an interrupter of suitable construction applied, and with or without an induction coil or similar means, or if the source of energy is obtained from a direct lighting circuit, a motor could be employed to drive a suitable generator to furnish the requisite current, or the current may be used direct without generator and passed

[*Price* 6*d*.]

through apparatus to give the required form to the current. If an alternating current is available this would simplify the apparatus used.

The intermittent, pulsating or alternating current thus obtained is passed through a coil of wire on a bobbin or former adapted to be adjusted endwise, laterally or angularly by suitable means such as a screw or the like to move it towards to away from or otherwise adjust it with relation to a similar coil on a separate bobbin or former preferably having a fixed position with relation to the adjustable coil. From the coil on the adjustable bobbin or former the current is then conducted to another coil fitted on the end of a flexible wire so that said coil may be passed over the surface of the body and thus act as a surface localiser, or the said coil may be located in a form of probe for insertion into a wound or cut.

In close proximity to the coil in the surface localiser or probe is a second coil which may be on the same bobbin or former, the two said coils being thoroughly insulated from each other so that any currents circulating in one coil cannot pass into the other except by induction.

The last mentioned coil is connected to the coil on the fixed bobbin or former adjacent the adjustable coil.

The currents circulating in one pair of connected coils will induce currents respectively in the other pair of coils. The coils are so connected that the currents induced by the coil on the adjustable bobbin or former in the coil on the adjacent bobbin or former are in an opposite direction to the currents induced with the coil in the localiser or probe in its companion coil, so that if all the coils are equal and under the same conditions no current can pass in the circuit of the coil on the fixed bobbin or former and its respective coil in the localiser or probe, but by the upsetting of the balance of either set of coils, a condition is set up which allows either the coil on the fixed bobbin or its respective coil in the localiser to generate more current, as for instance, if both pairs of coils are exactly balanced and a small piece of metal is brought near to the coils in the localiser or probe, the lines of force are more concentrated and one coil produces a current which being stronger than the current induced opposite thereto in the coil on the fixed bobbin is able to drive a current in the reverse way through said coil.

For the purpose of detecting the slightest trace of current flowing in the connected coils on the fixed bobbin and localised or probe, a telephone receiver is connected in the circuit and its sensitiveness is such that a very small fragment of metal held a distance away from either set of coils will cause the receiver to indicate that a current is passing.

Adjustment of one of the coils with respect to its neighbouring coils is essential for the reason that it is practically impossible to obtain the best results unless compensation is made for differences in the amount of wire in any of the coils, as for instance, when a probe is used the amount of wire wound therein varies according to the strength required.

Further a probe, owing to the smallness of its diameter, will not contain the same length of wire as a surface localiser and consequently the difference must be compensated for.

A suitable switch arrangement is provided in addition so that part of the wire on the adjustable bobbin or former and on the neighbouring bobbin or former can be cut out when using a probe.

By means of an apparatus in which the receiver and its induction coils are in one circuit while the fluctuating, intermittent or alternating current together with its inductive coil are in another circuit the two currents can be so delicately balanced by opposition that no currents are generated in the receiver circuit, and consequently no sound can be heard in the receiver, but the smallest trace of metal brought within range of the induction coils of the two circuits suffices to generate sufficient current in the receiver circuit to make it respond.

It will be understood that the details of arrangement and construction of the means described may be varied or modified without departing from the spirit and scope of the invention.

Dated this 25th day of July, 1917.

BARRON & LEWIN,
Palatine Chambers, Market Street, Halifax,
Agents for the Applicants.

COMPLETE SPECIFICATION.

Improvements in Means for Localising Metallic Bodies in Human or Animal Tissues or Non-metallic Substances.

We, JAMES WILLIAM GREENWOOD, of 49, Cheltenham Place, Halifax, in the County of York, Electrical Engineer, and EDWARD HAWKESWORTH HACKETT, of Heath Mount, Halifax, aforesaid, Surgeon, do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

This invention relates to means or apparatus of the electrical telephonic type comprising balanced primary and secondary circuits such as devised by Professor Hughes in which a primary circuit containing duplicate coils receives momentary or alternating currents which normally induce equal and opposite currents in duplicate coils in a secondary circuit containing an indicator operative only when the presence of metal causes a disturbance of the electric equilibrium and the currents in the secondary coils become unequal, and particularly, to such apparatus for detecting and localising foreign bodies or pieces of metal such as bullets, fragments of shrapnel shell and the like lodged in human or animal tissues, or of metals in nonmetallic substances, the object of our invention being the provision of improved and efficient means by which the position of the metallic body can be detected and its position accurately located either from the surface of the body or substance or by a probe inserted into the wound or cut.

The instrument or apparatus consists broadly of suitable regulating coils and switches for same mounted in a detachable case fitting within a small portable box and adapted to be secured to the top of the box or box lid when in use to remove it from metal parts of the instrument with which connection is made through the lid, a detector or searcher for passing over the surface of the body or substance or a probe for insertion into a wound or cut, said searcher or probe having two coils of insulated wire wound together in one coil or on a single bobbin connected by flexible cord to the regulating coils, means for cutting out varying lengths of wire to compensate for variations in the length of wire in the coils in the searcher or probe, and a telephone receiver also appropriately connected to the instrument. Current is provided in a simple and convenient form by a set of small dry cells and is passed through an interrupter before passing to the regulating coils, telephone receiver and double coil in the detector or searcher.

Our invention will be fully described, with reference to the accompanying drawing, in which:—

Fig. 1 is a transverse section of a box adapted to contain the complete instrument or apparatus, the case containing the regulating coils and parts being

shown in full line fitted on the top of the box in position for use, with the detector and searcher and telephone receiver connected thereto, and in dotted line stored away in a compartment in the box;

Fig. 2 is a section on an enlarged scale of the regulating coils and parts;

Fig. 3 is a section taken on line A. B of Fig. 1 showing the plate and connections for the telephone receiver and detector or searcher and the pins which pass through sockets in the box lid for connection to the interrupter;

Fig. 4 is an elevation of the interrupter, and

Fig. 5 is a diagram of the connections of the various parts of the instrument.

Referring to the drawing, the numeral 1 indicates a box to contain the whole of the instrument or apparatus said box being small and light and therefore easily moved about and adapted to be used in any convenient position. In compartments in the lower portion of the box are a battery 2 and an interrupter 3. The current required for the apparatus is very small, being less than 20 milliamperes so that a small battery of dry cells will serve for a considerable period of time and, when exhausted, can be replaced as easily as the refils for flash light lamps. In an upper compartment of the box normally rests a loose case or box 4 containing the regulating coils 5, 6 and switch 7 as shown in dotted line on Fig. 1, the said case being removable from the interior of the box and adapted to be secured to the lid 8 of same as shown in full line in Fig. 1 when the apparatus is to be used, pins 9 on a plate 10 secured to the case and having the appropriate wire connections being inserted through holes made in the box lid and making contact with wire connections represented at 11, to the interrupter 3.

The regulating coils 5, 6 are wound on respective bobbins or formers 12, 13 the former of which is secured to the upper wall of the case by screws or the like, or, as in the instance shown, by the screwed end of a spindle 14 extending through an opening in the second bobbin or former 13 and screwed through the bobbin 12 and into the wall of the case 4, the said spindle acting as a stop to prevent rotation of the bobbin 13 on a screwed spindle 15 on which it is mounted. The said screwed spindle 15 extends through a central opening in the bobbin 12 and has secured on its outer end a finger or pointer 16 provided at its rear end with a handle by which the said pointer and the screwed spindle can be rotated in either direction at will, a disc 17 having a graduated scale marked thereon being secured to the top of the case and enabling the operator to ascertain for purposes of comparison the extent of rotation made in either direction to obtain the regulation desired.

The rotation of the screwed spindle in one direction or the other causes the bobbin or former 13 to approach towards or recede from the bobbin 12 in known manner for securing a balance in the coils as will be hereafter described.

From the coil on the adjustable bobbin 13 connection is made by plug 18 and flexible wire 19 with an insulated coil which with a second insulated coil connected with the coil on the bobbin 12 are wound together on a bobbin or former located in a detachable instrument 20 comprising a searcher or detector having a flat face which is adapted to be passed over the surface of the body, the plug 18 having pins thereon which are adapted to extend through openings in the case 4 and enter openings in the plate 10 to make the necessary connections for the current to pass between the coils. The said coils in the searcher or detector are thoroughly insulated from each other, so that any currents circulating in one coil cannot pass into the other except by induction. A second pin plug 21 at the end of a flexible cord 22 to which is attached a telephone receiver 23, is adapted to be inserted through openings in the case 4 and into the plate 10 to make connection with wires connected with one of the regulating coils and one of the coils in the detector or searcher. The receiver 23 employed may advantageously be of the construction shown and described in the Specification of Patent No. 22,887 of 1914. The searcher is of the flexibly connected type such as previously proposed to detect the pre-

sence of torpedoes without contact but differs therefrom in that the two coils are wound together as one coil.

At 24 is shown an alternative instrument to take the place of the surface instrument 20 this comprising a probe for insertion into cuts or wounds, the two insulated coils being wound together and located or embedded in the centre of the material of which the probe is made. The said coils are necessarily small to suit the size of the end of the probe and therefore have less length of wire thereon. The probe is suitably connected to a flexible cord provided with a plug, as in the case of the surface detector or searcher, and can be used at any time in substitution for said searcher by removing the plug on the flexible cord connected to the latter and substituting therefor the plug on the flexible cord connected to the probe.

In using the probe, however, it is necessary by reason of the difference in the length of wire in the coils thereon as compared with the length of wire in the regulating coils, to equalise or regulate same, and for this purpose the switch 7 is employed and by moving said switch over against any of the contacts 26 (see Fig. 5) connected with the coil on bobbin 12, different lengths of wire in said coil can be cut out to reduce the effective length thereof to correspond with the length of wire on the coils in the probe.

The operation and connections of the instrument will be more readily followed by reference to Fig. 5. A switch 27 is placed at the on position shown in Fig. 5 and the intermittent, pulsating or alternating current passes from the battery 2 through the interrupter 3 which is provided with an armature connected to a sounding tongue having flexibility on each side of the armature and of a suitable length to give a long break to the current at each impulse of the armature and give good results, the said interrupter being preferably enclosed in a small case for silencing purposes and the sound further deadened by mounting said interrupter on short lengths of india rubber or like flexible tubing 28. After passing through the interrupter, the current passes through the coil of wire on the bobbin 13 and then through the coil *a* forming one of the two coils in the detector or searcher 20.

The currents circulating in the said pair of connected coils induces currents in the other pair of connected coils, namely in the coil on the bobbin 12 and in the coil *b* forming the second of the two coils wound together in the searcher 20 but in opposite directions, and if all the coils are equal and under the same conditions no current can pass in the circuit of the coil on bobbin 12 and its respective coil in the detector or searcher 20, as in previously proposed arrangements of balanced primary and secondary circuits.

Before using the instrument, the receiver is placed to the ear and if the least sound is heard the screwed spindle 15 is rotated to cause the bobbin 13 to approximate to or recede from the bobbin 12 in manner previously proposed until a balance is obtained whereupon, no sound being observed, the instrument is ready for service.

To detect and locate pieces of metal in the body, the receiver is held to the ear and the searcher then passed over the surface of the body where the presence of metal is suspected, and when the said searcher is brought near to or over a piece of metal embedded in the tissue, the balance of the coils is upset and allows either the coil on the bobbin 12 or its respective coil in the searcher to generate more current, as, for instance, if both pairs of coils are exactly balanced and a small piece of metal is brought near to the coils in the searcher the lines of force are more concentrated and one coil produces a current which being stronger than the current induced opposite thereto in the coil on the fixed bobbin 12, is able to drive a current in the reverse direction through the said coil. The same inductive effect would take place if the metal were brought near to the regulating coils, but this is not necessary in using a searcher.

As soon therefore as the balance is destroyed, a slight sound is heard in the

receiver and the presence of the metal thus not only denoted but by manipulation of the searcher over the part where metal has been detected the maximum increase of sound in the receiver will indicate the point of nearest approach where the metal is lodged and, when this is found, a pencil passed through a central opening 30 in the searcher enables the exact spot to be marked on the surface of the body whereby the surgeon or operator can judge accurately in making an incision to reach and remove the metal.

The probe searcher is used for insertion in a wound or cut and is of value also where an incision has been made at a wrong angle and has missed the object.

Each time a change is made in the form of the searcher used, that is to say from a surface instrument to a probe, or *vice versa*, the coils are regulated and, if necessary, more or less wire on the bobbin 12 is cut out to reduce the length of wire thereon to conform with the smaller length of wire on the coils in the probe searcher, said probe searchers being made of different sizes and therefore with varying lengths of wire in the coils.

The wires *c*, *d*, *e* and *f*, *g*, *h*, *i*, shown in Fig. 5 are respectively connected with the pins 9, 9, 9, and f^1, g^1, h^1, i^1, shown in Fig. 3, to make the circuits illustrated in Fig. 5. 31 is a condenser of the usual type.

In using the probe searcher, it is first sterilised and the connection thereof with the flexible cord, and the like connection on the surface searcher, are preferably protected by a flexible sheath to avoid the access of any moisture through the joints.

It is essential in each case before using the instrument to test it by holding the receiver to the ear and if the least sound is heard to regulate the coils by adjustment of the bobbin 13 until there is silence, the varying conditions in the room externally of the instrument, such as moisture, heat or the like having an influence on the instrument which must be neutralised before it is used to secure good results.

The metal is detected and localised without actual contact, and where an X ray photograph has been taken and the metal has shifted its position in the meanwhile or the patient is not in precisely the same position as when the photo was taken, the application of the instrument will be of great value in indicating the point of nearest approach to the metallic object before making the incision.

As described and shown on the drawing, the instrument is suitable for use in hospitals or operating rooms. For field work, we may enclose the parts in a small cylindrical or like case composed of celluloid or the like so that it can be carried in the pocket or suspended on the front of the tunic or coat. The apparatus would be precisely as above described but made smaller and with a single probe searcher permanently attached to the case. The body of the case having the regulating coils therein will itself comprise the surface searcher and be moved over the body to detect and localise the metal object, the telephone receiver being coupled to the instrument as before or permanently.

In this smaller instrument the switch for cutting out any portion of the wire in the coil on the fixed bobbin 12 would not be required, because the probe searcher being permanently connected to the instrument no variation in length of wire in the coils of the searcher has to be provided for.

Instead of the source of energy being obtained from a battery, it could be obtained from a direct lighting circuit, a motor being employed to drive a suitable generator to furnish the requisite current, or the current could be used direct without generator and passed through apparatus to give the required form to the current, but we prefer to employ the battery as this is simple, effective and gives the results desired. If a second condenser is inserted in series in the circuit *f*, *g*, *e* a further reduction would be effected in the consumption of current.

An apparatus or instrument such as above described could be employed for detecting metallic objects in non-metallic substances.

The instrument or apparatus can be used to distinguish between magnetic and non-magnetic metals. By adjusting the coils to secure silence as before described, and then moving the adjustable bobbin to or away from the fixed bobbin until a slight sound is heard, if, in the approach of the searcher towards any metal, the sound swells with a pure crescendo it denotes a non-magnetic metal, but if the note swells to a certain point and then a slight silent node is observed and on further approaching the metal the sound is again heard, this denotes a magnetic metal. The direction of the current flowing around the regulating coils determines whether the movable bobbin must be moved towards or away from the fixed bobbin to obtain the silent node above referred to. The advantage of being able to determine before operating whether the metal is magnetic or non-magnetic is of value to the surgeon because if magnetic it can be removed by a magnet from soft tissue such as the brain.

Having now particularly described and ascertained the nature of our said invention and in what manner the same is to be performed, we declare that what we claim is:—

1. In an electrical telephonic instrument or apparatus for detecting and locating foreign bodies or pieces of metal in human tissues or of metals in non-metallic substances by induction the combination with regulating coils one movable with respect to the other and a telephone receiver in circuit with one of said coils, of a surface or probe searcher or detector detachably connected by flexible cord to the instrument and provided with two insulated coils wound together in one coil or upon the same bobbin, one of said coils being in circuit with a battery or other suitable source of energy and the other with the telephone, a fluctuating, intermittent, or alternating current passing from the battery through an interrupter and then through the coils in circuit with the battery inducing currents in opposite directions in the coils in circuit with the telephone receiver, and means for cutting out varying lengths of wire in the regulating coils to compensate for variations in the length of wire in the coils located in the detector or searcher or probe, substantially as herein shown and described.

2. In apparatus according to Claim 1, a surface detector or searcher having a central opening therethrough whereby to mark the point of nearest approach to the detected metal in the tissue or substance, substantially as herein shown and described.

3. In apparatus according to Claim 1, an interrupter mounted on short lengths of india rubber or flexible tubing to deaden sound, and an armature connected to a relatively long sounding tongue to give a long break at each impulse said tongue having flexibility beyond each side or end of the armature to improve the results of the break action, substantially as herein shown and described.

4. The general arrangement, construction and combination of parts comprising the instrument or apparatus for detecting and locating metal in human tissues or in non-metallic substances, substantially as herein described and shown.

Dated this 24th day of January, 1918.

BARRON & LEWIN,
Palatine Chambers, Market Street, Halifax,
Agents for the Applicants.

Redhill: Printed for His Majesty's Stationery Office, by Love & Malcomson, Ltd.—1918.

[This Drawing is a reproduction of the Original on a reduced scale]

fig. 1.

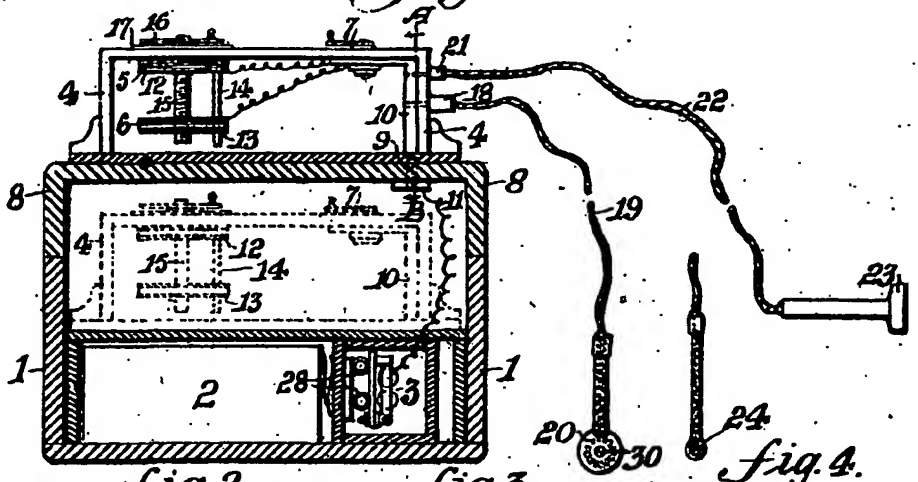


fig. 2.

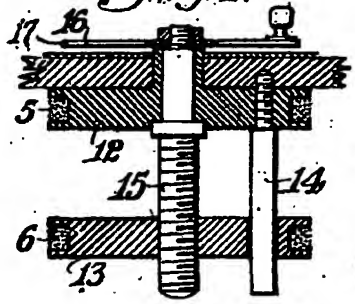


fig. 3.

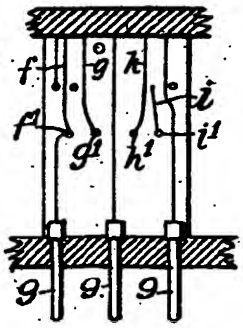


fig. 4.

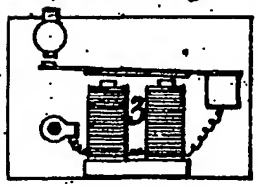
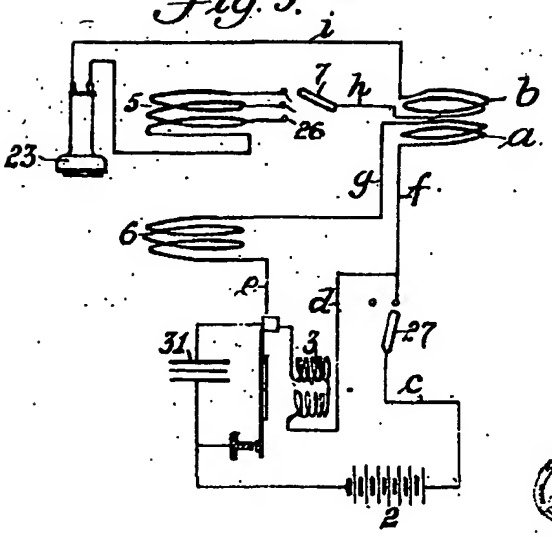


fig. 5.



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